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POLARIZATION EXCHANGE RESONANCE

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SPIN EXCHANGE RESONANCE OF FREE ELECTRONS*†

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The experimental work described in two earlier papers[1] has been continued with the final goal in mind to observe the electron resonance in a vacuum. Photoionization by means of Hg λ3131 radiation of Cs-atoms admixed to the Rb-sample has been employed throughout for the creation of slow electrons. Buffer gas pressure and sample size have been systematically reduced and it has been possible to record electron resonances at pressures as low as 1 mm argon in a sample as small as 30 cc with a signal to noise ratio of about 100:1. An improved vacuum cell, coated with dotriacontane, has been built, which, in a Cs-Rb spin exchange resonance experiment, exhibited Cs-relaxation times longer than 1 second. The Hg λ3131 radiation appeared to have no detrimental effect on the Rb-resonances observed in this sample whose residual pressure of about 10^{-4} mm also was unaffected. Since it was not possible to observe the electron spin resonance in this vacuum sample, an attempt was made to study the photoelectron cloud by cyclotron resonance absorption techniques.[2] Strong resonances, using oscilloscope broad band display, were observed at 6 mc employing rf fields as low as 10μv/cm. The strength

[1] H. G. Dehmelt, Phys. Rev. 109, 381 (1958), and Journal de Physique et le Radium 19, 866 (1958)

[2] Liebes and Franken, to be published

*Abstract of an invited paper given at the Ann Arbor Conference on optical pumping, June 15, 1959

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of the observed cyclotron resonance suggested a new double resonance technique in which the intensity variation of the cyclotron resonance, observed at fixed rf frequency in fixed magnetic field, is used to monitor the spin resonance. As has been pointed out[1] the large observed exchange cross sections indicate that the singlet and triplet scattering cross sections must be appreciably different, e.g., $Q_s \simeq 4\pi\lambda^2$, $Q_t \simeq 0$ as a limiting case. This inequality now provides the basis for the new technique since the intensity[2,3] of the cyclotron resonance depends on the e-Rb collision frequency and this in turn on the relative spin directions of electrons and Rb-atoms. Assume, e.g., electrons, completely polarized by exchange collisions, colliding with completely polarized Rb-atoms. Since the e- and Rb-spins are parallel, the triplet cross section, $Q_t \approx 0$, applies and the cyclotron-resonance should be narrow and intense. On the other hand, when the spins are antiparallel after the electron spins have been turned over by gyromagnetic resonance, an average cross section $1/2\ Q_s + 1/2\ Q_t \simeq 2\pi\lambda^2$ applies and the cyclotron resonance should be broadened and weakened. Analogous schemes should be applicable to cyclotron resonances of suitable ions in spin exchange equilibrium with alkali atoms. To get the long electron life times needed for narrow resonances, an electron trapping scheme employing two spectral lines in the ionizing radiation was used. The first, more intense, higher frequency line serves to create a positive space charge cloud of heavy ions. This positive space charge now traps the low energy electrons which are liberated by second weak spectral line whose energy is just sufficient to ionize the Cs atoms. Attempts to demonstrate the spin dependence of the cyclotron

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[3]Margenau, Phys. Rev., to be published

resonance intensity have not yet been successful - - probably due to the large electrostatic broadening[2], abor 1 mc, of the low frequency cyclotron resonance.